Clamping Cartridge for Panel-Type Products

Cross Reference to Related Applications

This application claims the benefit of U.S. Provisional Application No. 60/432,023 filed December 10, 2002 and U.S. Provisional Application No. 60/488,771 filed July 22, 2003. This application also claims priority based on Canadian Patent Application No. 2,413,688 filed December 9, 2002 and Canadian Patent Application No. 2,435,717 filed July 22, 2003.

Field of the Invention

The invention relates to a clamping apparatus for holding and positioning a plurality of items and, more particularly, a clamping cartridge for releasably clamping a plurality of generally planar objects.

Background of the Invention

There are numerous instances where a series of sheet or panel-type products need be transported and/or stored. When all such items are identical, there is usually no need to be concerned over loading and unloading sequences. However, when the items are not identical, any sequenced access must be predetermined which usually entails predetermined loading strategies and, furthermore, random access may simply not be possible. Moreover, where the items vary in thickness, group clamping typically requires individual (i.e. time-consuming) adjustment of respective clamping mechanisms.

Existing solutions are either cumbersome, inefficient and/or unable to address all of the user-defined requirements. These requirements and the challenges were, mainly, the following:

the ability to load a variety of panel sizes and thicknesses within a given packaging unit, for example in a custom metal rack;

the ability to access, remove or replace any one or all panels individually, without affecting the rest of the panels;

the ability to grip and hold the parts (panels) during transport and storage;

user-friendly operating sequences;

reliability and ease of maintenance; and

cost effectiveness.

U.S. Patent No. 2,946,453 describes a supporting rack for automobile windshields having a plurality of pairs of posts, half of which are fixed while the other half are associated with a movable frame so as to enable the movable posts to be moved in unison against the fixed posts to provide a clamping action therebetween. U.S. Patent No. 2,953,253 illustrates a windshield carrier having a pair of fixed parallel slotted frames for receiving windshields therein. Clamping is effected either by an associated pair of movable parallel frames having corresponding slots therein (Fig. 1) or a series of pressure elements movable through a linkage (Fig. 8). The devices of both of these patents have unitary movement of all clamping elements, but the fixed spacing structure will only function to clamp the thickest of a plurality of planar articles of variable thicknesses.

U.S. Patent No. 4,093,251 discloses a windshield carrier having a plurality of posts in two rows. A rotatable friction element is disposed atop each post which can be rotated into engagement with the surface of a windshield disposed between adjacent posts. The friction elements are individually rotatable. This device has the capacity to accommodate a plurality of planar articles of variable thicknesses, but each clamping mechanism must be operated independently.

U.S. Patent No. 4,202,452 shows a supporting rack for breakable articles comprising a plurality of spaced apart posts in parallel rows. An inflatable tube is provided on the exterior of each post and, thus, between adjacent posts. The tube is inflatable to contact the articles disposed between the posts in a secure and safe fashion. This apparatus has the capacity to accommodate a plurality of planar articles of variable

thicknesses and is operable to close and release all clamps in unison. However, the apparatus requires the hydraulic/pneumatic system to be operating/pressurized at all times when clamping is required. Thus, if the system fails, the clamping function ceases.

U.S. Patent No. 4,785,936 illustrates a device for holding flat objects, such as circuit boards, wherein a plurality of slots are provided in a tray having cooperating blocks with ridges moveable relative thereto. In order to accommodate a variety of thicknesses of boards, resilient cushions are disposed between the ridges which compress to the extent necessary. The device is spring biased in the open position. This device has the capacity to accommodate a plurality of planar articles of variable thicknesses and is operable to close and release all clamps in unison. Like with U.S. Patent No. 4,202,452, this apparatus is open in its relaxed state.

Summary of the Invention

A clamping cartridge is provided which comprises a plurality of clamping mechanisms spaced apart on a frame or chassis. The clamping mechanisms are generally oriented perpendicular to their direction of spacing, meaning that the clamping motion of all the clamps is in the direction of spacing so that panel-type products can be clamped in parallel to one another (which is perpendicular to the direction of spacing of the clamps). The clamping mechanisms are normally biased in a closed position and are openable in unison by way of an actuation mechanism in order to permit insertion of an edge of one or more articles to be clamped. While the clamps are also closeable in unison, they are individually self-adjusting so the extent of closure for each clamp is dependent on the thickness or presence of an inserted article.

Preferably, the clamping mechanisms are of the type which comprise a pair of relatively movable jaws which are biased together.

In one embodiment, the jaws are openable by levers which are connectable to or integral with the jaws such that when the end of the levers distal the jaws are moved relatively toward one another, the jaws are caused to open. The actuation levers extend through the frame where they engage a camming mechanism which is operable to urge together respective pairs of levers of each clamping mechanism so as to cause the plurality of clamping mechanisms to open in unison and to permit the respective pairs of levers of each clamping mechanism to separate so as to cause the jaws of the plurality of clamping mechanisms to close or clamp against one or more objects which may have been placed therebetween.

The camming mechanism may comprise a shaft supported by the frame in the direction of spacing of the clamping mechanisms and having thereon a plurality of cam wheels which are fixed to rotate with the shaft. The cam surfaces are disposed on the radial sides of the cam wheels rather than on the circumferential or perimetric edge. The cam surface varies in the axial direction with the revolution of the wheel. A pair of oppositely oriented cam surfaces are provided for each pair of levers of each clamping mechanism. The pair of cam surfaces engage the distal ends of the pair of levers of a clamping mechanism. As the shaft is rotated, the cam surfaces rotate causing the distance between respective pairs of cam surfaces at which the distal ends of the levers are engaged to decrease or increase, thereby actuating the ends of the pair of levers inwardly or outwardly respectively to open and close the jaws of the clamping mechanism.

Advantageously, the cam surfaces between adjacent clamping mechanisms can be provided on a single cam wheel for economy of manufacture.

One embodiment of the clamping mechanisms of the invention comprises a flexible split cylinder-like spring clamp, assembled with two rigid arms that are wider, flat and covered with a protective material (typically rubber dipped) at one end and narrower at the other end. The wider ends are designed to grip the product edge, while the narrow ends are designed to interface with the cam surface.

The clamps are spaced out for a convenient density and mounted on a support frame. A plurality of tapered cylindrical cams are placed underneath the clamps, inside the frame and on one side of each pair of arms. The cams are mounted on a keyed shaft that can be rotated by a handle, wrench or the like.

The rotation of the shaft turns the cams and thus moves the narrow ends of the arms against the springiness (bias) of each clamp, opening it. The distance between the two gripping ends of each pair of arms is at maximum (opening) when the cams have the widest section engaged.

The product(s) can then be introduced. The product is not designed to be seated onto the clamping system, but on a separate structure, that will only support the panels vertically, without any horizontal grip.

The clamp cartridge(s) are usually mounted under the floor level of a larger pack, or rack, or similar storage system. Only the gripping arms are extended upward and above the floor level.

Once product is inserted between the gripping ends of the opened arms, the shaft is rotated 180 degrees and the narrowest portions of the cams are positioned between the arms, thus relaxing the springiness of the clamp to a mere touch.

The gripping ends of the arms naturally move to grip the product, whatever its width. If product is not present, the gripping ands of the arms will move to a light touch (relaxed position). Although the individual clamps are individually biased towards a closed position, the device itself may or may not be normally biased to a closed position.

The operating mechanism of the clamping cartridge, i.e. the opening/closing mechanics, can be implemented in a variety of ways to permit unitary opening of the individual clamps while not restricting the clamps to close in an identical manner.

In this regard, an alternate operating mechanism for the clamping cartridge is disclosed herein in which the serial, individual cam action of the aforesaid clamping cartridge is substituted with a single lift plate, which can be activated by a simpler camming mechanism.

In the alternate embodiment, the clamping cartridge still comprises a plurality of clamping mechanisms spaced apart on a frame or chassis. The clamping mechanisms are generally oriented perpendicular to their direction of spacing, meaning that the clamping motion of all the clamps is in the direction of spacing so that panel-type products can be clamped in parallel to one another (which is perpendicular to the direction of spacing of the clamps). The clamping mechanisms are of the type which comprise a pair of relatively movable jaws which are normally biased together.

In the alternate embodiment, the jaws are elastic and normally biased closed. The jaws are openable by a slotted plate that can slide perpendicularly to the direction of clamping which acts as the actuation mechanism. While a slot could be provided for each jaw, preferably, one slot is provided for each pair of adjacent jaws. Movement of the plate and brings together the jaw half belonging to two different, adjacent jaws, against the elasticity of the material, thereby opening the active clamping space, which is normally closed when empty.

The slotted plate is part of a platform that is moveable relative to the frame and which is confined to a translational movement along end guides and along the direction of the panels to be clamped.

The moving platform with the slotted section is positively activated in both directions by a camming mechanism which is operable to ultimately urge together respective pairs of arms of each clamping mechanism so as to cause the plurality of clamping mechanisms to open in unison and to permit the respective pairs of arms of each clamping mechanism to separate so as to cause the jaws of the plurality of clamping

mechanisms to close or clamp against one or more objects which may have been placed therebetween.

Preferably, the camming mechanism comprises a shaft supported by the frame in the direction of spacing of the clamping mechanisms and having thereon at least one cam wheel which is fixed to rotate with the shaft. Depending on the length of the cartridge, two or more cam wheels could be employed to ensure uniform lifting/lowering of the platform.

Preferably, there are a pair of cam surfaces, one at each end of the cartridge, and disposed inside a U-shaped channel/housing associated with the moving platform. The cams are mounted on a shaft that can be rotated by a wrench, lever or similar handle means. The rotation of handle causes the slotted surface of the platform to move up or down the length of the clamps' jaws. The cam surface varies in the radial direction with the revolution of the wheel.

One embodiment of the clamping mechanisms of the alternate embodiment of the invention comprises a flexible tulip-like spring clamp, covered at the ends with a protective material (typically rubber dipped). The jaws extend from the bight of the clamp and converge towards their tips.

The main features and advantages of the clamping cartridges according to the invention are: versatility in typo-dimensional product sequencing and access patterns, simplicity of operation and ease of maintenance.

The operating principles that are believed to be unique to this invention are described by a normally closed, spring based clamping action, self-adjusting grip strength proportional to the product thickness and simultaneous action on all cartridge clamps, regardless of product presence.

While minimum panel spacing depends clamp-to-clamp open position geometry which is a function of maximum thickness and flatness of the panels expected to be accommodated, the overall applicability is only limited by scale factors, as they relate to industrial means of transport and logistics.

In summary of the foregoing, there is provided a clamping cartridge for releasably clamping a plurality of panel-type articles in generally parallel spaced-apart manner comprising:

a frame;

a plurality of clamping mechanisms spaced-apart along the frame, the clamping mechanisms being generally oriented perpendicular to their direction of spacing and being normally biased towards a closed position;

actuation means operable in association with the clamping mechanisms for opening and closing the clamping mechanisms in unison;

the clamping mechanisms being individually self-adjusting upon closing.

Preferably, the clamping mechanisms comprise a pair of relatively movable jaws and the actuation means is operable on the jaws for overcoming the closing bias.

Other features and advantages of the invention will become apparent from the following description and drawings.

Brief Description of the Drawings

Fig. 1A is a perspective view of the clamping cartridge according to the preferred embodiment of the invention in its closed/clamping position. Fig. 1B is an elevational view of the clamping cartridge of Fig. 1A. Fig. 1C is a plan view of the clamping cartridge of Fig. 1A. Fig. 1D is an end view of the clamping cartridge of Fig. 1A;

Fig. 2A is a perspective view of the clamping cartridge according to the preferred embodiment of the invention in its open/released position. Fig. 2B is an elevational view of the clamping cartridge of Fig. 2A. Fig. 2C is a plan view of the clamping cartridge of Fig. 2A. Fig. 2D is an end view of the clamping cartridge of Fig. 2A;

Fig. 3A is a plan view of the spring body of one of the clamping mechanisms shown in the clamping cartridge of Fig. 1A. Fig. 3B is a bottom view of the spring body of Fig. 3A. Fig. 3C is an elevational view of the spring body of Fig. 3A. Fig. 3D is an enlarged end elevational view of the spring body of Fig. 3A;

Fig. 4A is a side elevational view of one of the clamp arms of one of the clamping mechanisms shown in the clamping cartridge of Fig. 1A. Fig. 4B is an end elevational view of the clamp arm of Fig. 4A. Fig. 4C is a plan view of the clamp arm of Fig. 4A;

Fig. 5A is a plan view of the support frame of the clamping cartridge of Fig. 1A. Fig. 5B is a side elevational view of the support frame of Fig. 5A. Fig. 5C is an end elevational view of the support frame of Fig. 5A;

Fig. 6A is a perspective view of one of the cam wheels of the clamping cartridge of Fig. 1A. Fig. 6B is an elevational view of the cam wheel of Fig. 6A. Fig. 6C is a plan view of the cam wheel of Fig. 6A. Fig. 6D is a side elevational view of the cam wheel of Fig. 6A;

Fig. 7A is a plan view of the cam shaft of the clamping cartridge of Fig. 1A. Fig. 7B is an elevational view of the cam shaft of Fig. 7A. Fig. 7C is an end view of the cam shaft of Fig. 7A. Fig. 7D is an elevational view of an alternate cam shaft having a different mechanism for its rotation. Fig. 7E is an end view of the alternate cam shaft of Fig. 7D;

Fig. 8A is a perspective view of the clamping cartridge according to the preferred embodiment of the invention in which a number of panel-type articles have been retained. Fig. 8B is an elevational view of the clamping cartridge of Fig. 8A. Fig. 8C is a plan view of the clamping cartridge of Fig. 8A. Fig. 8D is an end view of the clamping cartridge of Fig. 8A;

Fig. 9 is an elevational view of an alternate embodiment of the clamping cartridge according to the invention, shown in its closed/clamping; and

Fig. 10 is an elevational view of the alternate embodiment of the clamping cartridge of Fig. 9 but shown in its position open/released position.

Fig. 11A is a perspective view of the clamping cartridge with the alternate operating mechanism in its closed/clamping position according to the preferred embodiment of the invention. Details are shown in Figs. 11B, 11C and 11D which illustrate respectively an elevational view, a plan view and an end elevational view of the clamping cartridge of Fig. 11A in its closed position.

Fig. 12A is a perspective view of the support frame or chassis of the clamping cartridge of Fig. 11A. Fig. 12B is an elevational view of the support frame. Fig. 12C is a plan view of the support frame. Fig. 12D is a left end view of the support frame. Fig. 12E is a right end view of the support frame;

Fig. 13A is a perspective view of the cam housing of the clamping cartridge of Fig. 11A. Fig. 13B is an elevational view of the cam housing of Fig. 13A. Fig. 13C is a plan view of the cam housing of Fig. 13A. Fig. 13D is an end view of the cam housing of Fig. 13A;

Fig. 14A is a perspective view of the cam shaft of the clamping cartridge of Fig. 11A. Fig. 14B is an elevational view of the cam shaft of Fig. 14A. Fig. 14C is an end view of the cam shaft of Fig. 14A;

Fig. 15A is a perspective view of one cam of the clamping cartridge of Fig. 11A. Fig. 15B is an elevational view of the cam of Fig. 15A. Fig. 15C is an side view of the cam of Fig. 15A;

Fig. 16A is a perspective view of the movable channel of the clamping cartridge of Fig. 11A. Fig. 16B is an elevational view of the movable channel of Fig. 16A. Fig. 16C is an end view of the movable channel of Fig. 16A;

Fig. 17A is a perspective view of one of the slats for the movable channel of the clamping cartridge of Fig. 11A. Fig. 17B is an elevational view of the slat of Fig. 17A. Fig. 17C is an end view of the slat of Fig. 17A;

Fig. 18A is a perspective view of one of the clamping mechanisms of the clamping cartridge of Fig. 11A. Fig. 18B is an elevational view of the clamp of Fig. 18A. Fig. 18C is an end view of the clamp of Fig. 18A;

Fig. 19A is a perspective view of a retainer for the clamp of the clamping cartridge of Fig. 11A. Fig. 19B is a plan view of the retainer of Fig. 19A. Fig. 19C is an elevational view of the retainer of Fig. 19A. Fig. 19D is an end view of the retainer of Fig. 19A;

Fig. 20A is a perspective view of the handle or crank for the cam shaft of the clamping cartridge of Fig. 11A. Fig. 20B is an elevational view of the handle of Fig. 20A. Fig. 20C is an end view of the handle of Fig. 20A;

Figs. 21A-21D illustrate the clamping cartridge with the alternate operating mechanism as shown in Fig. 11A-11D in its closed position;

Fig. 22A is a perspective view of the clamping cartridge with the alternate operating mechanism being initially activated to commence opening of the clamping mechanisms. Details are shown in Figs. 22B, 22C and 22D which illustrate respectively an elevational view, a plan view and an end elevational view of the clamping cartridge of Fig. 22A in the beginning stages of opening.

Fig. 23A is a perspective view of the clamping cartridge with the alternate operating mechanism continuing to be actuated during opening of the clamping mechanisms. Details are shown in Figs. 23B, 23C and 23D which illustrate respectively an elevational view, a plan view and an end elevational view of the clamping cartridge of Fig. 23A in an intermediate stage of opening.

Fig. 24A is a perspective view of the clamping cartridge with the alternate operating mechanism actuated to a fully-opened position. Details are shown in Figs. 24B, 24C and 24D which illustrate respectively an elevational view, a plan view and an end elevational view of the clamping cartridge of Fig. 24A in an intermediate stage of opening.

Fig. 25 is a perspective view of a transportation/storage rack illustrating the use of the clamping cartridge of Fig. 1A;

Fig. 26 is an alternate perspective view of the rack generally opposite to that shown in Fig. 25;

Fig. 27 is a close-up of one of the rack's side clamping cartridges;

Fig. 28 is a close-up of one of the rack's bottom clamping cartridges; and

Fig. 29 is a close-up, perspective end view of the lower portion of the rack.

Detailed Description of the Invention

Referring to Figs. 1A-1D, there is shown an exemplary arrangement of the clamping cartridge 10 according to the invention. The clamping cartridge 10 comprises a plurality of spaced apart clamping mechanisms 12 arranged on a chassis or frame 14. The clamping mechanisms 12 (hereinafter referred to as clamps 12) have a pair of clamping arms 16 which cooperate with a spring clip 18 which urges the upper ends 20 of arms 16 toward one another in a jaw-like fashion. The lower ends 22 of

the clamping arms 16 project through the frame 14 and act as levers which when moved relatively toward one another overcomes the spring force of the spring clip 18 thereby causing the clamp 12 to open (as seen in Fig. 2B). The resiliency of the spring clip 18 biases the clamp 12 toward a closed position.

The clamping cartridge 10 also includes means to actuate (open/close) the clamps 12 which preferably comprises a series of rotatable cam wheels 24, each of which having a cam surface 26 in contact with the lower end 22 of a clamp arm 16. The cam wheels 24 are disposed on a rotatable cam shaft 28. Advantageously, the cam wheels 24 can be provided with a cam surface 26 on each side, allowing the cam wheels 24 to be interdigitated between adjacent arms 22a of adjacent clamps 12. Accordingly, for any number N of clamps 12, only N+1 cam wheels 24 are required.

The cam shaft 28 includes an extension 30 which can be used to rotate the cam shaft 28 and thus cam wheels 24. The extension 30 may be provided with means to facilitate rotation of the cam shaft 28, such as a knob or handle, or may include a lug which can be engaged by a wrench or similar tool. In the embodiment shown in Figs. 1A and 2A, a handle 31 is insertable into a transverse aperture 29 (see Figs. 1B and 2B) to effect leveraged rotation of shaft 28.

The cam surface 26 of the cam wheels 24 is axially and rotationally inclined such that by rotating the cam wheels 24, the point of contact with the lower end 22 of clamp arm 16 effectively translates axially. The cam surface 26 can be that which effectively results from an oblique cutting of a circular cylinder (i.e. a generally elliptical surface) as is the case in the preferred embodiment or could be a helical surface spiraling oppositely from both ends of the cam wheel (not shown).

As shown in particular in Figs. 6A-6D, the cam surfaces 26 are such as to provide the cam wheels 24 with a thinner section on one side 32 and a thicker section on the opposite side 34. As seen in Fig. 1B, the thinner sections 32 of the cam wheels 24 are disposed between the adjacent lower ends 22a of clamping arms 16 permitting

maximum opening between the lower ends 22 of each clamp 12 and thus minimizing the distance between or closing (depending on the spatial relationships) the upper ends 20 of each clamp 12. The outermost cam wheels 24a are disposed adjacent the lower end 22b of the outermost clamp arm 16a on outermost clamps 12a. While it is not necessary that the outermost surface 26a of outermost cam wheels 24a be a cam surface, manufacturing efficiencies are achieved in producing a single or minimum number of cam wheel configurations.

Referring to Figs. 2A-2D, when the cam shaft 28 is rotated such as by handle 31, the cam wheels 24 rotate so as to cause an increasingly thicker section thereof to wedge between adjacent lower ends 22 of adjacent clamps 12, thereby actuating the clamping arms 16 and thus opening the clamps 12' in unison. Preferably, the amount of rotation of cam shaft 28 to effect full opening and closing of the clamps 12 is 180° (or less). If the cam surface 26b,26c on both halves with of the cam wheel 24 is generally the same (i.e. the cam surface 26 is symmetrical about a vertical plane P as shown in Fig. 6D) then such a design will permit rotation of the cam wheel 24 in both directions (clockwise and counterclockwise) with the same effect.

A transverse chamfer 36 may be provided at the thickest section 34 in which the respective lower ends 22 of clamping arms 16 will center and seat when the clamps 12' reach their fully open position. This allows the clamps to "lock" at or near their fully open position to permit items to be inserted into the clamps 12' or removed therefrom. The chamfer also permits closer spacing of the clamps 12, 12' and serves to reduce pressure on the cam wheels 24.

Details of the components of the clamping cartridge 10 are shown in Figs. 3A to 7D.

Figs. 3A-3D show the spring clip 18 the purpose of which in general is to provide biasing which urges the clamp 12 toward a closed or clamping position. The spring clip 18 has a generally U-shaped cross-section as shown in Fig. 3D having a pair of

spring arms 40 separated by a bight 42. It will be appreciated that the spring clip 18 can be made in a variety of cross-sectional shapes.

The spring clips 18 are fastened to the frame 14 by any conventional means. In embodiment shown, and pair of holes 44 are provided in the bight 42 while corresponding holes 44 are provided in frame 14 (see Fig. 5A) through which appropriate fasteners 48 (see Figs. 1B, 2B and 2C) are used to secure the spring clip 18 to the frame 14.

The spring clips 18 are provided with a pair of slots 50 which correspond generally with pairs of slots 52 in frame 14 (see Fig. 5A). The slots 50 accommodate and help retain spring arms 16 while the slots 52 permit the spring arms 16 to extend through the frame 14 (as shown best in Fig. 1B). Preferably, the tips 54 of the spring arms 40 are sufficiently close such that when both clamping arms 16 are disposed within slots 50, the upper ends 20 of the clamping arms 16 are biased together. In Fig. 1B, the upper ends 20 of the clamping arms 16 are shown slightly separated. This is due to the fact that the insertion of the thinner sections 32 of the cam wheels 24 causes a slight pressure on the lower ends 22 of the clamping arms 16, thus causing the slight separation. Preferably, the spring clips 18 are made from known elastic materials such as spring steel.

Figs. 4A-4C show one of the spring arms 16 of the clamp 12. The upper ends 20 may be relatively wider than the lower ends 22 to provide extended clamping/gripping support along a portion of the product edge. In this regard, the upper ends 20 may be covered or coated with a protective, high-friction material to reduce possible damage to the product to be clamped and to increase the clamp's gripping capability. For example, the upper ends 20 may be dipped in a liquid settable rubber compound. The lower ends 22 are designed to interface with the cam surface and thus may be provided with a rounded edge 56 to enable slippage to a certain extent. Preferably, the spring arms 16 are made from relatively stiff

materials, such as stamped steel, so as to reduce the amount of bending over the force range expected to be encountered.

The frame 14 is shown in detail in Figs. 5A-5C. The frame 14 provides the basic supporting structure for the clamps 12 and cam shaft 28 (as shown in Fig. 1B). Thus the frame 14 may be conveniently made by bending an appropriate sheet material into a three sided, rectilinear configuration having an elongated central section 60 and two end sections 62. As aforesaid, the central section 60 includes holes 44 by which the clamps 12 are affixed thereto by fasteners 48 and slots 50 through which the clamping arms 16 of the clamps 12 extend. The end sections 62 each include an aperture 64 in which the cam shaft 28 can be journaled or in which a bearing for the cam shaft 28 can be provided. The frame 14 may also include mounting flanges 66 which include holes 67 for mounting the cartridge 10 where desired. While the preferred frame 14 has been shown with open sides 68 which reduces material costs and facilitates manufacturing thereof, the sides 68 can be closed where it is desired to restrict access to the cam wheels 24 or to inhibit ingress of dust and other foreign matter into the working components of the cartridge 10.

The cam wheel 24 is shown in detail in Figs. 6A-6D. When viewed along its axis (Fig. 6D), the cam wheel 24 has an outer circular configuration. The cam wheel 24 includes a central bushing 70 and an aperture 72 by which the cam wheel 24 can be mounted on the cam shaft 28. The aperture 72 includes a keyway 74 for accommodating a key 76 (see Fig. 1B) associated with the cam shaft 28 to prevent the cam wheels 24 from rotating relative to the cam shaft 28. The cam angle θ is generally a function of the diameter of the cam wheel 24 and the desired longitudinal movement of the lower ends 22 of the clamping arm 16 (to effect a correspondingly opposite proportional movement of its upper end 20 and hence an opening of the clamp 12).

Preferably, the cam wheels 24 are individual and identical for greater manufacturing efficiency and flexibility. Depending on the length of bushing 70, a cam wheel 24

may abut the bushing 70 of an adjacent cam wheel 24 (as shown in Fig. 1B) or may be relatively free to move along the keyed cam shaft 28, there being a certain degree of self-centering/alignment on account of the clamping arms in the latter case. Still, if spacing between cam wheels becomes significant, (required by panel separation and/or clamp size), washers may be introduced, as a precaution or as a visual enhancement, although they may not be required for the operability of the device. Alternatively, the cam wheels may be made integrally with one another. The cam wheels 24 may be made from any suitable material such as metal (steel, aluminum, etc.), hard plastics, Teflon™, etc. and they can be machined, stamped, injection molded, or any other suitable method of manufacture. The material should provide mechanical robustness, and a reasonable life-time under friction. The materials for the cam wheels 24 and the contacting portion of the clamping arms 22 can be chosen to have a sufficiently high coefficient of friction such that the cam wheels 24 will remain in whatever position they are in when rotation of the shaft is stopped (which may or may not be at top or bottom dead center). Alternatively, the chosen materials can have a sufficiently low coefficient of friction whereby the pressure exerted by the clamping arms 22 on the camming surfaces 26 causes the cam wheels 24 to rotate toward the clamp closed position, thereby resulting in a clamping cartridge which is normally biased in the closed position.

Lastly, the cam shaft 28 is detailed in Figs. 7A-7C. The shaft 28 has two annular grooves 80 spaced apart slightly greater than the distance between end sections 62 of frame 14 for accommodating retaining rings 82 (as shown in Fig. 1B). The shaft 28 has a keyway 84 which cooperates with key 76 (as shown in Figs. 1B and 1D) to enable rotation to be imparted from the shaft 28 to the cam wheels 24. Alternatively, a splined shaft could be provided with the apertures in the cam wheels being correspondingly splined. The shaft 28 may be made from any suitable material typically used for shafts.

Figs. 7D and 7E illustrate an alternate mechanism for assisting in the imparting of rotational movement in the form of a lug 29' which is provided on the extension 30'

of alternate shaft 28'. A wrench (not shown) is engageable with the lug 29' for rotating the shaft 28'. Any other known mechanism could likewise be employed for manual rotation of the shaft or a power-driven device could easily be substituted.

Referring to Figs. 1B, 2B and 8A-8D, to operate the clamping cartridge 10, the cam shaft 28 is rotated by the handle means 31, which causes the cam wheels 24 which are keyed to the cam shaft 28 by key 76 to rotate. As the section of the cam wheel 24 disposed between adjacent clamps increases in thickness, relatively speaking, or alternatively, as the distance between the upper ends of adjacent cam wheels 24 decreases, the clamps 12 are urged toward an open position 12' but remain biased against the force of the spring clips 18. As the cam shaft 28 rotates to 180°, the lower ends 22 of the clamping arms 16 self-center against the chamfered edge 36 of the cam wheel 24, thereby retaining the clamping cartridge 10 in its open position. In the cartridge's open position as shown in Fig. 2B, the individual clamps 12' are open to receive a portion of the edge(s) 90 of the panel-like object(s) 92 (shown schematically). One or more panels 92 (having a total thickness less than the design width of the open clamp 12') are positioned in one or more of the open clamps 12' and the cam shaft 28 is again rotated (either through to 360° or back to 0°) to close the clamps 12 against the inserted panel(s) 92. Since each of the clamps 12 are individually biased toward a closed position, the clamps 12 will naturally adjust to the thickness of the retained panel(s) 92 as shown best in Fig. 8B. Accordingly, the clamping cartridge 10 can accommodate a series of different panels comprising panels of different thicknesses 92a,92b and/or a varying number of panels 92c,92d of same or different thickness within each clamp 12, as shown in Figs 8A-8D. This will permit variability in loading or unloading (i.e. random access) and typo-dimensional sequencing for products retained within the clamping cartridge 10. When release or removal of one or more panels 92 is desired, the cam shaft 28 is rotated 180° in the same manner as aforesaid to open the clamps 12 in unison. When the desired panels have been removed, the cam shaft 28 can be actuated again to close clamps 12 against the remaining panels.

The individual biasing of the clamps 12 can be achieved in a number of ways. The embodiments shown herein employ a clip-type spring although this is not to be considered limiting. The positioning of the spring clip 18 in the aforementioned embodiments is shown to be above the frame 14. However, depending on the nature of the spring or biasing mechanism being used, positioning can be varied just so long as the function remains.

Instead of having the jaws of the clamp used to clamp the article and the clamping arms (levers) bearing on the camming surface of the cam wheels, the clamps can be reversed such that the jaws engage the opposed camming surfaces of the cam wheel and the articles are then clamped between adjacent clamping arms of adjacent clamps as shown in the alternate embodiment illustrated in Figs. 9 and 10. The alternate clamping cartridge 120 shares many of the same components as the clamping cartridge 10 of Fig. 1A, such as the cam shaft 28 and associated cam wheels 24. The frame 122 is similar but its dimensions may require alteration to accommodate the clamps 124 in their reverse orientation. The clamps 124 are disposed such that their spring clips 126 are beneath the frame 122 and with their arms 128 extending thereabove through the slots 130 in the frame 122. The thin section 32 of the cam wheels 24 are positioned between the jaws 132 of the clamps 124 such that the tips 134 of the clamping arms 128 engage the opposed camming surfaces 26 of the cam wheels 24. As the shaft 28 is rotated, the portion of the cam wheels 24 between the jaws 132 becomes increasingly thicker, relatively speaking, causing the distal ends 136 of the arms 128 of each clamp 124 to move relatively toward one another and hence away from the distal end 136 of the adjacent arm 128 of the adjacent clamp 124. Continuing the rotation to 180° as shown in Fig. 10, the jaws 132 over-center onto the chamfers 36 to "lock" into an opened position. Panels 140 which may have been disposed between adjacent arms 128 of adjacent clamps 124 are then removable. Alternately, panels 140 may be situated between adjacent arms 128 of adjacent clamps 124 whereupon rotation of the shaft 28 (either through to 360° or back to 0°) returns the thinner section 32 of the cam wheels 24 to between the jaws 132, relaxing/reducing the tension on the spring clips

126, and reducing the distance between the distal ends 136 of the adjacent arms 128 of the adjacent clamps 124, which effectively permits them to act as clamps.

The outermost clamps 124a,124b as shown in Fig. 9, may include only one clamping arm 128a,128b, respectively, as an outermost clamping arm 128c, shown in phantom, would be unnecessary in this arrangement. However, an outermost arm 128c could be provided. It can be seen that the alternate clamping arrangement 120 requires the same number of clamps 124 as cam wheels 24. However, the number of cam wheels 24 is still one greater than the number of clampable articles 140 as the clamping function is based on the spacings between adjacent clamps 124.

Referring to Figs. 11A-11D, there is shown the clamping cartridge 211 having the alternate operating mechanism which represents the best mode according to the invention.

The components of the clamping cartridge 211 are referenced with numerals 201 through 210, details of which are shown in Figs. 12A-12D to 20A-20D. The clamping cartridge 211 is similar to the clamping cartridge 10 shown in Figs. 1A-8D, especially in operation, the difference being mainly related to the manner by which the individual clamping mechanisms are actuated between opened and closed positions and vice versa.

Clamping cartridge 211 comprises a plurality of spaced apart clamping mechanisms 208 (see Figs. 18A-18C) arranged on a chassis or frame 201, similar to frame 14 of Figs. 1-8. The clamping mechanisms 208 (hereinafter referred to as clamps 208) have a pair of clamping arms or jaws 216 which are normally inwardly biased (for example, if made of spring steel or the like) so that the tips 235 thereof converge together so as to close the clamp 208 in the absence of external forces. The individual clamps 208 are affixed to the frame 201 by means of respective retainers

209 (see Figs. 19A-19D) and suitable fasteners, not shown, which secure the bight 242 of the clamp 208 to the frame 201.

For opening the jaws 216 of the clamps 208, a movable slotted guide 213 is provided through which the jaws 216 of the clamps 208 extend. Preferably, the guide 213 is constructed of a channel 206 (see Figs. 16A-16C) having a plurality of spaced-apart slats 207 (see Figs. 17A-17C) affixed transversely thereto by suitable fasteners, not shown, through holes 231 in the slotted guide 213 (see Fig. 16B) and holes 227 in slats 207 (see Fig. 17B), for example. The spaced-apart slats 207 provide therebetween a number of transverse slots 215 through each of which a pair of jaws 216, that is adjacent ones from adjacent clamps 208, extend therethrough, with the exception of the outermost clamps wherein only the single outermost jaw extends therethrough. It will be appreciated that individual slots could be provided for each jaw but the sharing of slots 215 between adjacent jaws will make the guide less complex. The slotted guide 213 is movable relative to the frame 201. By moving the slotted guide 213 in the direction of the opening of the clamp, the jaws 216 are constrained within the slots 215 and are thereby forced to pivot towards perpendicular from their normally inwardly angled position as the distance between the frame 201 and guide 213 increases and back as the distance between the frame 201 and guide 213 decreases. The channel 206 has sufficient depth D (see Fig. 16C) to accommodate the length of travel required to fully open the clamps 208, which is generally at least the length of the jaws 216. Use of individual retainers 209 and slats 207 facilitate assembly.

A camming mechanism is employed to control the movement of the slotted guide 213 relative to the frame 201. One or more (two as shown in the drawings) cam housings 202 (see Figs. 13A-13D) are affixed to the slotted guide 213, particularly on the underside of channel 206, using suitable fasteners, not shown, through holes 225 in the slotted guide 213 (see Fig. 16B) and holes 227 in housings 202 (see Fig. 13A), for example. Braces 203 are be welded to the cam housings 202 for strengthening purposes and or to assist with guiding the movement of the slotted

guide 213 and cam housings 202 as shown in Fig. 13A. Each cam housing 202 encloses a cam wheel (or simply "a cam") 205 (see Figs. 15A-15C) which is mounted on a mutual cam shaft 204 (see Figs. 14A-14C) which extends though slots 217 in the cam housing 202 and is rotatably mounted to frame 201 through apertures 219 (see Fig. 12A). Cam surface 223 contacts both inner sides of housing 202.

The cam shaft 204 includes an extension 230 which can be used to rotate the cam shaft 204 and thus cam wheels 205. The extension 230 may be provided with means to facilitate rotation of the cam shaft 204, such as a handle 210 (see Figs. 20A-20C), or may include a lug which can be engaged by a wrench or similar tool. In the embodiment shown in Fig. 11A, the handle 210 is screwable into a transverse threaded aperture 229 (see Fig. 11C) to effect leveraged rotation of shaft 204.

For ease of manufacture, the cams 205 are circular, but are mounted via off-centre aperture 221 with respect to the cam shaft 204. By rotating the cam shaft 204, the cams 205 rotate and urge their cam surface 223 against the cam housing 202, causing the housing 202 to move relative to the frame 201, hence the reason for slots 217 in the housings 202. Depending on friction between the contacting components, the rotational position may be self-maintaining, but preferably, low friction components are utilized so that the biasing force of the clamps 208 against the slots 215 is sufficient to always urge the clamping cartridge into its closed position.

Thus, as with the embodiments illustrated in Figs. 1A-8D and Figs. 14-15, the clamping cartridge 211 also employs a camming mechanism to effect unitary operation of the individual clamps.

Referring to Figs. 21A-21D to 24A-24D, to operate the clamping cartridge 211, the cam shaft 204 is rotated by the handle means 210, which causes the cam wheels 205 which are affixed to the cam shaft 204 to rotate. The rotation of the cams 205

causes the cam housings 202 and hence the slotted guide 213 to move relative to the frame 201. Initially, as shown in Figs. 22A-22D, nominal movement occurs. However, continued rotation of the handle/cam shaft/cams 210,204,205 as shown in Figs. 23A-23D results in greater relative movement of the slotted guide 213, with the confinement of the slots 215 causing the straightening (towards perpendicular) of the jaws 216 of clamps 208 by overcoming the closing bias of the jaws 216. At the fully rotated position shown in Figs. 24A-24C, the jaws 216 of clamps 208 are fully opened to receive therebetween (or release) a portion of the edge(s) of the panel-like object(s) 92 (shown schematically). The handle 210 may then be reversely rotated (or forwardly rotated through 360°) to cause the slotted guide 213 to lower, thereby relaxing the bias-overcoming force and eventually retaining the panel-like object 92 between the jaws 216 of the clamp 208.

Since each of the clamps 208 are individually biased toward a closed position, the clamps 208 will naturally self-adjust to the thickness of the retained panel(s) 92. Accordingly, the clamping cartridge 211 can accommodate a series of different panels comprising panels of different thicknesses and/or a varying number of panels of same or different thickness within each clamp 208. This will permit variability in loading or unloading (i.e. random access) and typo-dimensional sequencing for products retained within the clamping cartridge 211. When release or removal of one or more panels 92 is desired, the cam shaft 204 is rotated in the same manner as aforesaid to open the clamps 208 in unison. When the desired panels have been removed, the cam shaft 204 can be actuated again to close clamps 208 against the remaining panels 92, if any.

The clamping cartridges 10, 120, 211 can be used in a variety of storage and/or packaging systems. The cartridges can be used in a variety of containers like hard (plastic) bins, totes, wooden and even paper (cardboard) structures, as well as on carts, cars, dollies, elevators, conveyors, or in fixed applications (on walls, on floors, on structures of any kind). In one such application shown in Figs. 25-29, a glass-panel storage rack 300 is realized comprising a frame 302 to which a generally

horizontal bottom support 303a and a generally vertical side support 303b are attached. At least one clamping cartridge 10 (as shown, or clamping cartridge 120 or 211) is preferably provided in association with each support 303a,303b such that the clamping mechanisms 12a of the horizontal support cartridge(s) 10a align in the same plane with the corresponding clamping mechanisms 12b of the vertical support cartridge(s) 10b. The clamping cartridges 10a,10b can then be opened as aforesaid so as to enable the edges 304a,304b of glass panels 305 to be positioned within the clamps 12a,12b, respectively. The clamping cartridges 10a,10b can then be closed as aforesaid so as to clampingly retain the glass panels 305 within the rack 300.

When any one of the glass panels 305 is to be removed, the clamping cartridges 10a,10b are opened and the panels 305 can be removed as desired. Although when the clamping cartridges 10a,10b are opened, all of the clamping mechanisms release, the edges 304a,304b of glass panels 305 are still bounded by the clamping arms 16 (jaws) and thus the panels 305 should remain in place until removed. However, it may be desirable to incline the rack 300 to take advantage of gravity to ensure the panels 305 stay in the rack 300 when the clamping cartridges 10a,10b are opened. In the embodiment shown in Figs. 25-29, the frame 302 is maintained generally upright while the bottom and side supports 303a,303b are tilted as shown by angle α in Figs. 25, 26 and 29.

The rack 300 may also include separate seating/supporting devices 306 (shown best in Figs. 27, 28 and 29) for the panel whereby the weight of the panels is supported thereby. The clamping cartridges 10a,10b are positioned such that the jaws 20 are engageable with the edge portion 304a,304b of the panels 304 without the panels' weight resting on or abutting against the bight 42 of the clamps 12 as shown, for example, in Fig. 27. In this regard, the rack 300 separates the gripping/clamping task/function from the gravitational, supporting functions. The use of separate seating/supporting devices 306 reduces the need for more robust clamps and provides more economical cushioning and surface distribution capability versus having it built into the clamps. As shown, the seat/supports 306 have a multiple-U-

shaped cross-section seen best in Fig. 29, which is attachable to convenient locations on the bottom and side supports 303a,303b, wherein the parallel channels 308 are aligned generally with the clamps 12 of the clamping cartridges 10. In the case of the lower seat/supports 306a on the bottom support 303a, the edge bearing surfaces 310 extend above the bights 42 of the clamps 12 of the cartridges 10a but not above the upper ends of the arms 20, whereas the edge bearing surfaces 310 of the side seat/supports 306b on the side support 303b, extend inwardly of the bights 42 of the clamps 12 of the cartridges 10b but not beyond the upper ends of the arms 20.

Depending on the arrangement of clamping cartridges 10 and seat/supports 306 in a given rack 300, it may be possible to use the rack 300 to store or transport not only a plurality of identical articles, but also differing articles. As can be seen in Figs. 25 and 26, different sets of glass panels 305a,305b,305c are retained in the rack 300 although only three of the four clamping cartridges 10 are used, only two of which are common to all sets of glass panels 305a,305b,305c. Fig. 28 shows how the seat/supports 306 cradle the remote (from the clamps) edges 304c of the glass panel 305c. Depending on the clamping strength and the article to be clamped, it may only be necessary to employ one clamp 12 per article (hence a single clamping cartridge 10) and, where necessary, utilize one or more aligned seat/supports 306 to support and prevent movement of non-clamped edges.

The seat/supports 306 can be made of any appropriate material bearing in mind the articles expected to be transported or stored in the rack 300. As shown, the seat/supports 306 are made from an extruded plastics material.

Advantageously, the bottom and side supports 303a,303b can comprise a plurality of slats 312 on which the clamping cartridges and seat/supports 306 are mounted. By having the slats 312 moveable/adjustable with respect to the frame 302 and hence the spacing between adjacent clamps, the rack 300 can readily be adapted to accommodate a wide variety of articles.

Depending on the number of clamping cartridges employed in any one rack and their accessibility, it may be advantageous to provide a linkage mechanism (not shown) to operate them simultaneously or to utilize power-driven shafts with an associated control unit (not shown) to selectively rotate the shafts individually or simultaneously.

Since the clamping cartridges 10, 120, 211 function in the same manner, their use in a rack 300 would be the same as explained above with clamping cartridge 10.

While there has been shown and described herein a clamping cartridge for panel-type products and a rack for its application, it will be appreciated that various modifications and or substitutions may be made thereto without departing from the spirit and scope of the invention.